A method to evaluate the accuracy of ionospheric tomographic reconstructions using incoherent scatter radar scans

Jon Bruno*, Karl H.A. Bolmgren, and Cathryn N. Mitchell
Department of Electronic and Electrical Engineering, University of Bath, U.K.

Abstract

Ionospheric data assimilation and ionospheric tomography are both methods that can create a realistic representation of the 3D electron density distribution. While multiple techniques have been developed over the past 30 years there are relatively few studies that show the accuracy of algorithms. This paper outlines and demonstrates a new approach that uses incoherent scatter radar (ISR) scans of the ionosphere and extrapolates them to create a realistic test model ionosphere. Fictitious observations can then be created using actual measurement geometries from GPS satellites and receivers that can then be used as a test data set where the 'real' ionosphere, coming from the ISR-based model, is actually known.

Simulated observations of differential phase delay from GPS satellites are used in an inversion algorithm called MIDAS (Multi Instrument Data Analysis Software) [1], to estimate the spatial distribution of electron density. Ionospheric images over Northern Europe will be presented using this algorithm. The main issue using ground-based GPS for ionospheric reconstruction is the lack of vertical accuracy. When reconstructing the ionosphere adequate vertical profiles, that estimate the electron's behaviour over height, are needed. The algorithm will then try to fit the resulting electron density to those given profiles.

In this paper sets of empirical orthonormal functions (EOFs) for the vertical profiles are created using different basis sets. The resulting reconstructions are then compared with the truth ionosphere across a wide area, and the truth ionosphere is used to calculate the difference between each of the reconstructions and the truth, in terms of maximum error and mean error for the area of interest.

References

[1] C. N. Mitchell and P. S. Spencer, "A three-dimensional time-dependent algorithm for ionospheric imaging using GPS," *Annals of Geophysics*, vol. 46, no. 4, pp. 687–696, 2003.